

The Role of the Atlantic Overturning Circulation in Abrupt Climate Change

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Final Report

I. North Atlantic Cross-Basin Density Gradient and Overturning Strength over the last 30 kyr.

We have developed benthic oxygen isotope records from the cores from the Senegal margin (a collaboration with Stefan Mulitza at Bremen). We now have detailed records from 5 cores between 500 – 3000 m water depth. All of the benthic oxygen isotope records show pronounced shifts to lower values at the times of the Heinrich Events. Work in Mulitza's lab has shown that Mg/Ca does not change appreciably at the time of the Heinrich events, suggesting that these excursions reflect changes in seawater $\delta^{18}\text{O}$, most likely linked to changes in the source areas for these waters. When we compare the LGM $\delta^{18}\text{O}$ data from the 5 Senegal cores to LGM data from the Western North Atlantic [Keigwin, 2004], there is no discernable difference between the two sides of the basin. This is consistent with the idea that cross-basin density contrast and shear in the overturning circulation was weak during the LGM as we inferred earlier from cores in the South Atlantic [Lynch-Stieglitz *et al.*, 2006].

II. Florida Straits Density Structure and Flow during Heinrich Event 1

Graduate Student Dana Ionita completed her studies with a regional ocean model in which she assessing the impact of a sea level lowering on flow through the Caribbean and the Florida Straits. She found only a small reduction due to the change in bathymetry, and this is now published in *Paleoceanography* [Ionita *et al.*, 2009].

We have generated high resolution records on the Florida Straits benthic foraminifera for the Younger Dryas and Heinrich Event 1 to better constrain the magnitude and duration of the circulation changes in the Florida Straits associated with these events. During the Younger Dryas, we have sufficient resolution in our core at the Bahamas to show a reduced gradient in $\delta^{18}\text{O}$ and presumably density across the Straits. This likely reflected the reduced meridional overturning circulation and flow through the Florida Straits (*Figure 1*). The apparent reduction in flow through the straits during the Younger Dryas has an abrupt onset, coincident in time to the cooling in Greenland, and the changes in tropical hydrology (*Figure 2*). The return to modern conditions starts when Greenland warm but occurs more gradually taking on the order of 500 years to complete the recovery. The high resolution Younger Dryas record is now in press at *Paleoceanography*.

Preliminary work on the expression of Heinrich Event 1 in the Florida Straits under this grant has been continued through H3 under a grant from NSF. We now have

good evidence for circulation changes over Heinrich Event 1, but no evidence for change over Heinrich Events 2 and 3 (*Figure 1*). We currently have a manuscript in the final stages of preparation based on this work.

While he was a post-doc supported by this grant Matthew Schmidt generated records of SST and $\delta^{18}\text{O}$ of seawater from Mg/Ca measurements on planktonic foraminifera over the course of the Younger Dryas and the Heinrich Events on the cores from the Florida Straits. He currently has two manuscripts in preparation based on this work.

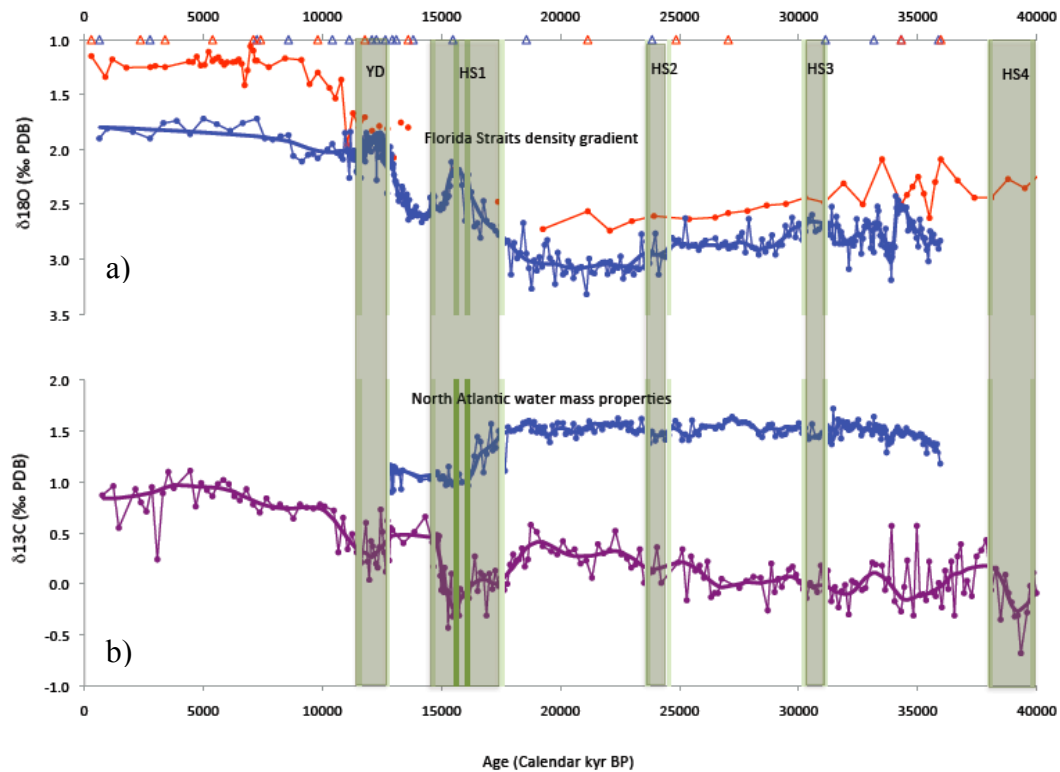


Figure 1: a) The $\delta^{18}\text{O}$ of benthic foraminifera on the Florida Margin (blue) is reduced during Heinrich Stadial 1 and during the Younger Dryas. During the Younger Dryas, we have sufficient resolution in our core at the Bahamas (red) to show a reduced gradient in $\delta^{18}\text{O}$ and presumably density across the Straits. This likely reflected the reduced meridional overturning circulation and flow through the Florida Straits. For Heinrich Stadial 1 we see a similar reduction in density on the Florida Margin, presumably also associated with circulation changes. However Heinrich Stadials 2 and 3 are not accompanied by similar changes in density along the Florida Margin. b) Benthic foraminiferal $\delta^{13}\text{C}$ both at our intermediate water site in the Florida Straits (blue), and in deep waters (2384 m, purple) [Mulitza *et al.*, 2008] show no evidence for water mass changes over Heinrich Stadials 2 and 3 of the same magnitude as those seen during Heinrich Stadial 1, supporting the idea that the circulation changes associated with these glacial Heinrich events were minimal.

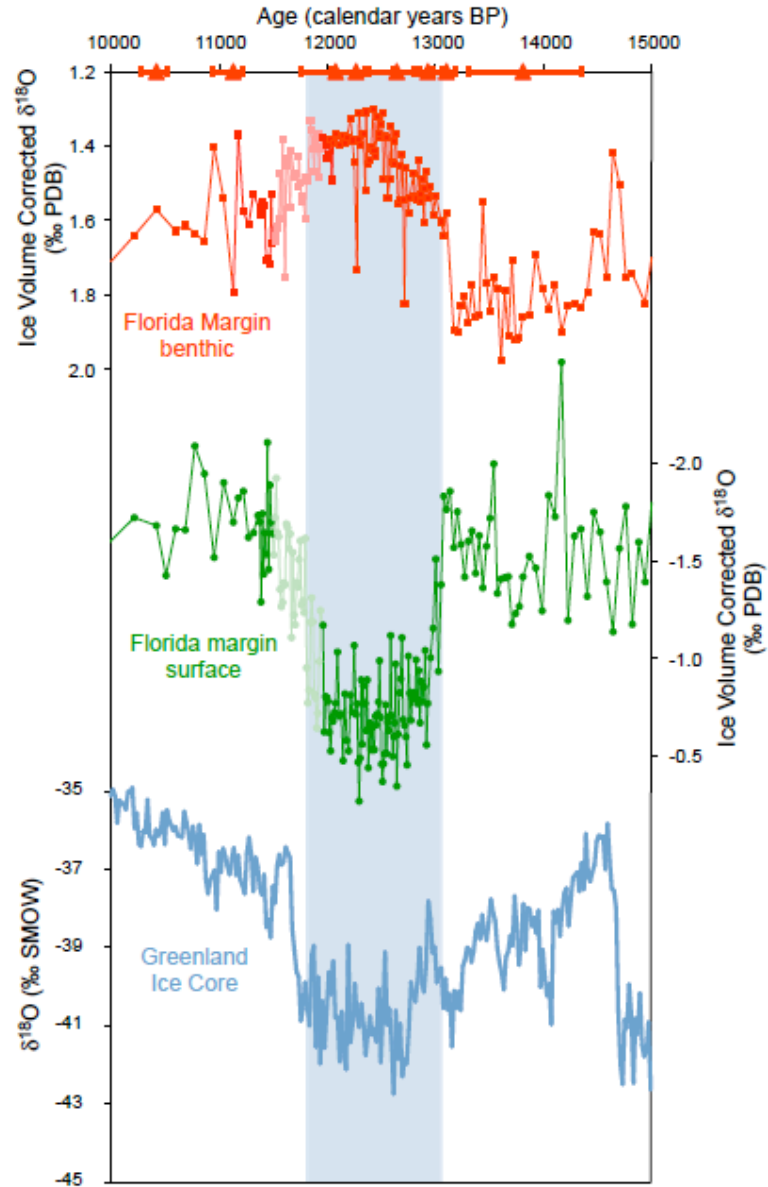


Figure 2. a) Detail of the benthic foraminiferal (*C. pachyderma*) $\delta^{18}\text{O}$ on the Florida Margin. Lower resolution records from the Bahamas show that the Younger Dryas $\delta^{18}\text{O}$ gradient across the Florida Straits was reduced relative to the modern (Fig 1). Here, the low values of ice volume corrected $\delta^{18}\text{O}$ during the Younger Dryas are interpreted as a reduction in the cross straits density gradient (low velocity shear associated with low flow through the straits) [Lynch-Stieglitz *et al.*, in press]. b) Planktonic (*G. ruber*) $\delta^{18}\text{O}$ from the same sediment core, also corrected for whole ocean changes. High values during the Younger Dryas reflect colder and/or saltier water. c) The Younger Dryas interval as expressed in the isotopic composition of snow accumulating on Greenland (low $\delta^{18}\text{O}$ during cold interval) [Andersen *et al.*, 2004; Rasmussen *et al.*, 2006]. Both the planktonic (sea surface conditions) and benthic (circulation) records show an abrupt transition into the Younger Dryas.

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